Child-Centred Risk Assessment for Pacific Island Countries and Territories

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August 2016

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Child-Centred Risk Assessment for Pacific Island Countries and Territories

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Children at risk in the Pacific

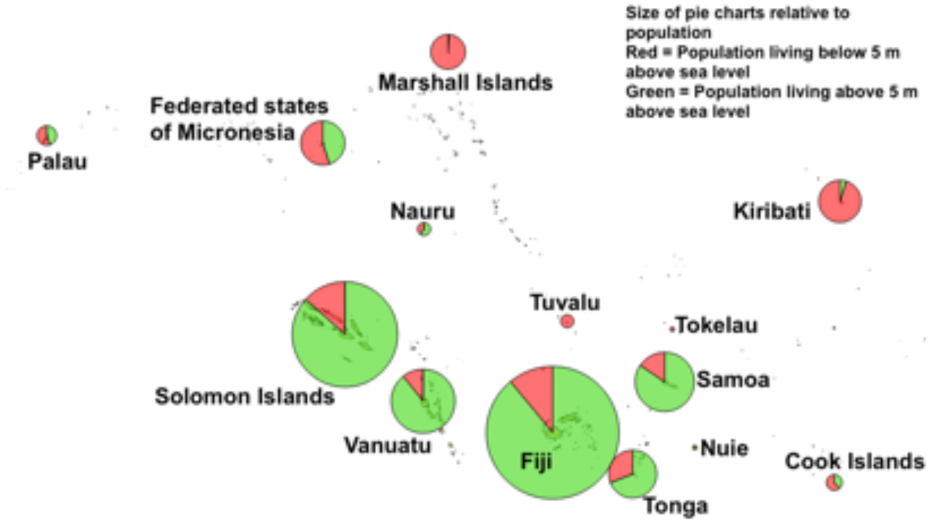
Pacific Island Countries and Territories (PICTs) are scattered across the world's largest ocean and exposed to a wide range of hazards. The edge of the oceanic Pacific plate is among the most seismically active tectonic boundaries in the world, resulting in earthquakes, tsunamis and volcanoes, thus earning it the nickname "the "Pacific Ring of Fire". The Pacific is also the birthplace and home to tropical cyclones, which are called "typhoons" north of the equator and "cyclones" south of the equator. These tropical cyclones not only cause wind damage, but also heavy precipitation and storm surge, which in the case of the latter can travel far and affect distant countries. In addition to storm surge and king tides that inundate low-lying areas (coastal floods), heavy precipitation can make rivers breach their banks (fluvial floods) and overwhelm the available drainage capacity of local topographical low points (pluvial floods). Both heavy precipitation and earthquakes can trigger landslides in hilly areas, while too little precipitation can result in droughts with severe and far-reaching consequences. Rainfall patterns are heavily influenced by the El Niño Southern Oscillation (ENSO), which also affects the frequency and intensity of tropical cyclones. Although disease outbreaks and epidemics are always possible, their likelihood is significantly aggravated in disaster situations. Erosion is threatening coastlines, and pollution can destroy sensitive natural resources that many depend upon.

The 14 PICTs covered by the UNICEF Pacific Multi-Country Office[1] (Figure 1) are home to 2.4 million people (SPC, 2014) over a land area of 65,000 km^2. They include many of the smallest countries in the world in both population and size, but also some of the largest in terms of their exclusive economic zone (EEZ).[2] Most of their populated islands have had human settlements for thousands of years. Accordingly, there is a rich cultural heritage providing traditional knowledge, tools and strategies for resilience. However, societies are changing rapidly in terms of economic development and urbanization, as well as in their aspirations and lifestyles; consequently, traditional ways of responding to climate change are being lost or are inapplicable in the growing towns and cities. Moreover, there is not a single corner of the Pacific that is not affected by climate change, which causes a rise in the sea level, increased erosion and saltwater intrusion in low-lying areas. The effects of climate change also include rising temperatures and altered rainfall patterns in general, as well as aggravated risks of extreme weather events. This is particularly challenging for PICTs, where significant proportions of their populations live in low-lying areas (Figure 1). Reducing risk and adapting to climate change is thus a prerequisite for sustainable development, which have been identified by both policymakers and civil servants across the Pacific, who show unprecedented concern and attention to these challenges.

[1] Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Niue, Palau, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu.

[2] For example, Kiribati ranks 12, Federated States of Micronesia ranks 14 and Marshall Islands ranks 19.

Figure 1. Relative population size and proportion living below 5 m above sea level



Source: Based on World Bank(2012).

The one million children in the 14 PICTs are disproportionately affected by disasters and the impacts of climate change, and constitute 42 per cent of the total population (SPC, 2014). However, not all children are equally at risk or evenly affected in disasters. This variation is only partly due to disparities in exposure to different hazards, indicating that some children live in areas that are more likely to be affected than others. It is also due to inequities between children in terms of access to vital resources, so that two children equally exposed to a specific hazard may be affected differently. However, being poor, marginalized and voiceless regularly increases their exposure, because they are forced to live in dangerous locations due to lack of other and often more expensive options. To reduce risk and adapt to climate change, the governments and their partners need to systematically map where children at risk are located and to focus their efforts accordingly.

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Background and data availability in the Pacific

UNICEF supports governments in a range of areas, including health, nutrition, water, sanitation, hygiene promotion, education and child protection, in line with the Convention on the Rights of the Child, ratified by all of the PICTs. UNICEF also supports governments in their response and recovery from disasters, which are all too common in the Pacific and which repeatedly undermine years of development in mere seconds (e.g. earthquakes), hours (e.g. cyclones) or months (e.g. droughts). To help inform decisions and support activities towards reducing risk and adapting to climate change, UNICEF has developed a methodology for Child-Centred Risk Assessment that has already been used to map children at risk in a number of countries (UNICEF, 2014), including India, Indonesia, Lao PDR, Nepal and Pakistan. The methodology has been adapted for each specific context and now to the specific context and data availability of PICTs.

Available data in the Pacific is provided through the work of the Secretariat of the Pacific Community (SPC), which provides easy access to geospatial data on hazards through their Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), data on exposure, and data for approximating vulnerability through their Pacific Regional Information System (PRISM) Project. These state-of-the-art sources of data facilitate elaborate risk mapping for all PICTs, including Papua New Guinea. The geospatial risk assessment methodology presented here is tailored to this situation and is developed from the original Child-Centred Risk Assessment used in other parts of the world. It can be used in any of the PICTs engaged in SPC's PCRAFI and PRISM Projects, or with access to other sources of census data. The methodology and actual risk assessments were developed in close collaboration with Molino-Stewart, an Australian based consultancy firm focusing on natural hazards, risk management and environmental issues.

A methodology for Child-Centred Risk Assessment for the Pacific

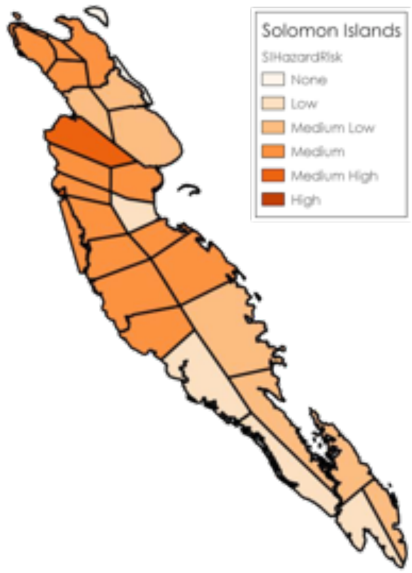
Purpose and utility

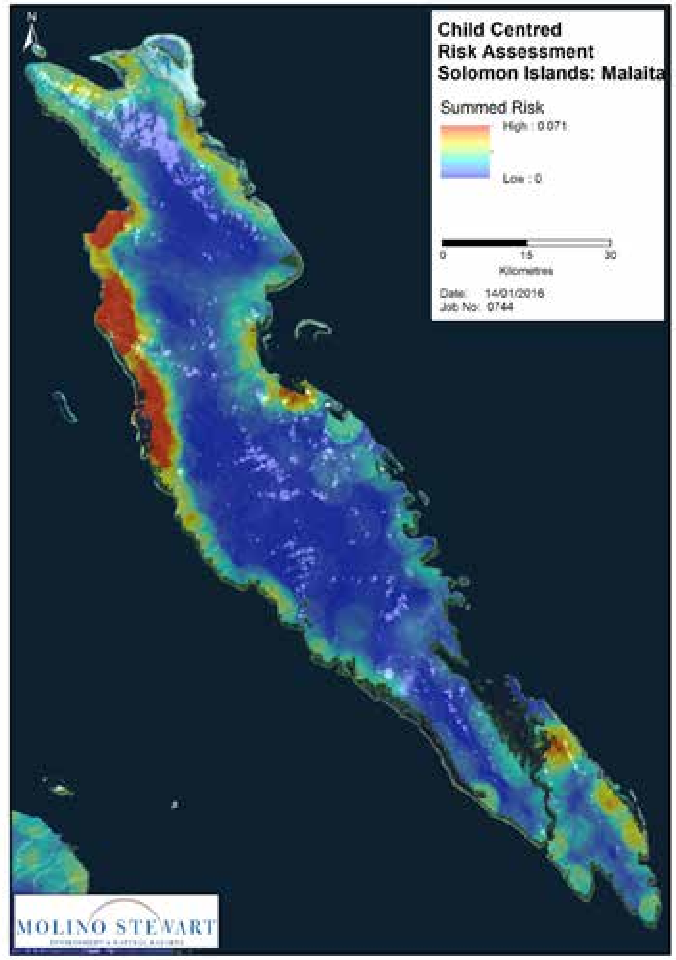
Child-Centred Risk Assessment has been performed in a number of countries. Although assessments use different approaches, they all involve collating data on hazards, exposure and vulnerability (and sometimes capacity) to produce a spatial distribution of risk. Here, "hazard" is defined as events that, under specific circumstances, can trigger a destructive chain of events, often referred to as "emergencies" or "disasters"; "exposure" is defined as the number of children who are affected by the hazard; and "vulnerability" is defined as the sensitivity of children to a hazard that determines how severely they are affected.

The aim of the approach here is to produce a relative distribution of risk that can be compared across space and serve risk-informed decision-making concerning the focus of activities for children at risk. Child-Centred Risk Assessment is thus an essential tool for risk-informed programming. However, its results cannot be interpreted in an absolute sense (i.e. comparing the specific results in one risk assessment with results in another assessment), but only within risk assessments using the same data and assumptions.

Differences from other Child-Centred Risk Assessments

To date, Child-Centred Risk Assessments have been undertaken on different administrative levels depending on the country, from the provincial level to the enumeration area, assuming that each entire area is equally exposed to hazards and that the children in that area are equally distributed within it (Figure 2). These assumptions are problematic in the Pacific, where hazards often vary in impact across space, and children reside in villages, towns or other settlements, and are not spread uniformly. The data available for PICTs through SPC facilitate a more detailed analysis of the spatial distribution of hazards and children (Figure 2), which is detailed below.


Solomon Islands
SIHazardRisk
None
Low
Medium Low
Medium
Medium High
High


N
Child Centred
Risk Assessment
Solomon Islands: Malaita
Summed Risk
High : 0.071
Low : 0
0
15
30
Kilometres
Date: 14/01/2016
Job No: 0744
MOLINO STEWART

Child-Centred Risk Assessment

Moreover, the Child-Centred Risk Assessments carried out in other parts of the world were all based on the assumption that children are equally vulnerable to different hazards. This is fundamentally wrong, since vulnerability is not a general characteristic of a child, but must always be related to a specific hazard. For instance, children living in a shack in an informal settlement may be much more vulnerable to tropical cyclones that destroy their homes and hurl deadly debris than children living in a brick building in a better-off area next door. However, the situation might be reversed for earthquakes, which may destroy both children's houses but pose a much greater risk of death and injury for the child in the brick building, with its heavier structure turned into dense rubble. A child in a household dependent on rainwater harvesting is more vulnerable to drought than a child in a household connected to a reticulated water system, but might be less affected and recover quicker if affected by an earthquake. The list of examples can be long; however, essentially, the risk is neither composed only of exposure to hazards, nor only of socio-economic status, but rather, risk is combination of hazard exposure and vulnerability to that particular hazard. Accordingly, the Child-Centred Risk Assessment for PICTs differentiates the vulnerability to different hazards by using different assumptions and algorithms to approximate them.

Finally, the original methodology for Child-Centred Risk Assessment focuses solely on the geographical distribution of societal risk by including the distribution of children. Although this is fundamental for identifying areas of highest risk in terms of number of anticipated disaster-affected children, it is likely to hide where the most at-risk individual children might be. For example, an area with ten times more children will still have a higher societal risk, even if the children in the more populated area are only half as vulnerable to the impact of the hazard. However, the individual risk is higher in the area with the fewer but more vulnerable children, given the same hazard. The equity focus of UNICEF thus demands that the methodology for Child-Centred Risk Assessment for the Pacific also take into account the geographical distribution of individual risk, i.e. the risk that a child is exposed to depending on his/her location, regardless of the number of other children present.

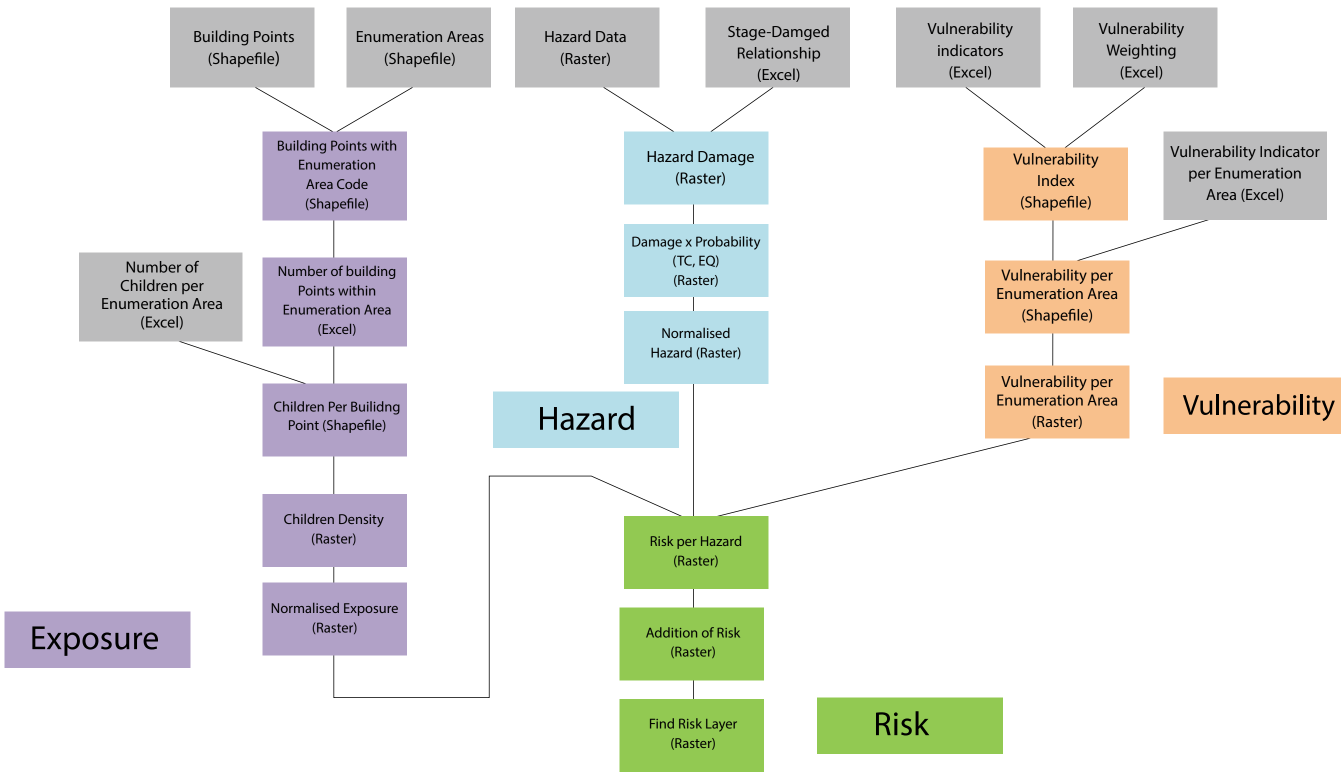
Introducing the process of Child-Centred Risk Assessment for the Pacific

The methodology for Child-Centred Risk Assessment for the PICTs can be illustrated as a process with three parallel parts, i.e. the mapping of the geospatial distribution of hazard, exposure and vulnerability. These parts are ultimately combined into a geospatial distribution of risk (Figure 3). The steps for each of the three parts and their mergence are described in more detail in the following sections. The aim of these steps are generally to improve the spatial resolution of the data or their representativeness.

The invaluable base data on tropical cyclones and earthquakes, for instance, are provided in technical units that do not directly convey meaningful impacts on the communities. A wind speed of 100 km/hour once every 50 years may generate much greater risk than a wind speed of 200 km/hour every 500 years. Similarly, a wind speed of 100 km/hour may create much more than twice the amount of damage than a wind speed of 50 km/hour. Accordingly, the base data must be transformed following a set procedure explained below.

Regarding exposure data, the main purpose of the steps in the process is to improve the spatial representativeness by disaggregating the enumeration area counts of children down to a finer scale based on available building counts. The underlying reason for disaggregating is that many enumeration areas are large enough for significant variation of population density across it. For example, an enumeration area may be 95 per cent uninhabited and have a single town covering 5 per cent of the area but housing 100 per cent of the children. This is problematic for two reasons. First, if it is assumed that all children are equally distributed across the enumeration area, this could either highly underestimate exposure if the town is located in a high hazard area, or underestimate exposure if the town is located in a low hazard area. Second, spreading the total number of children over a large area always underestimates the actual population density and may thus hide at-risk hotspots in the analysis (see Figure 2). Distributing children in relation to where there are buildings in the enumeration area mitigates both these problems, since it better approximates the actual location of the children.

Figure 3. Overview of the process of Child-Centred Risk Assessment for the Pacific



Hazards

Although the Pacific is subject to a wide range of hazards with different spatial extents, speed of onset, duration, likelihood and intensity, Child-Centred Risk Assessment requires geospatial data to analyse the distribution of risk across the islands. This limits the selection of hazards to be included and sends a clear signal concerning the important work of SPC's Geosciences Division to continue to develop and provide datasets for more hazards. To date, SPC has provided detailed hazard datasets for earthquakes and tropical cyclones through the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI),[3] and a more basic dataset for drought is provided by Columbia University.

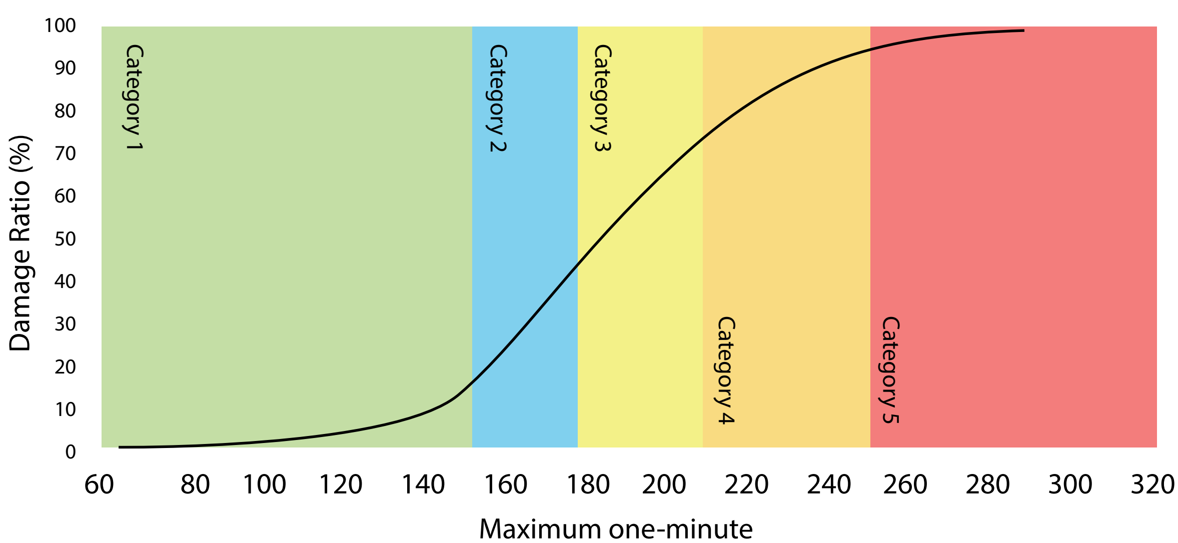
Tropical cyclone

The hazard data for tropical cyclones are provided as a raster grid with a resolution of 0.001 degrees, or approximately 100 metres. The data are expressed as the maximum one-minute sustained wind speed for a given probability, expressed as average return intervals (ARI), (e.g. once in a hundred years). The provided return intervals varies slightly between countries, but sufficient data are available from PCRAFI for Fiji, Kiribati, Solomon Islands, Vanuatu, Cook Islands, Federated States of Micronesia, Marshall Islands, Nauru, Palau, Samoa, Tokelau, Tonga, and Tuvalu, as well as for Papua New Guinea and Timor-Leste.

The maximum one minute sustained wind speed is essentially the highest wind speed maintained for a minute or more during a storm, which is an important measure of the destructiveness of the tropical cyclone, even if it is likely that there are shorter gusts of higher wind speeds. Although tropical cyclones are also capable of producing storm surge and significant rainfall that may cause floods and landslips, they are difficult to quantify on such a large scale, and data on their impacts are not included in the available datasets.

The destructive capacity of different wind speeds is not linear, but has been shown by PCRAFI to follow a continuum. They initially slowly increase damage as a tropical cyclone intensifies to category 1, then it rapidly increases damage as wind speeds increase through categories 2 and 3, before the increase in damage begins to decelerate at the already catastrophic wind speed of categories 4 and 5 (Figure 4). To factor in this important stage-damage curve in the Child-Centred Risk Assessment the geospatial distribution of maximum sustained wind speed for each available return period is recalculated by a GIS-software (ArcGIS), using a piecewise linear equation, which results in a new raster with the geospatial distribution of damage (%) for each return period.

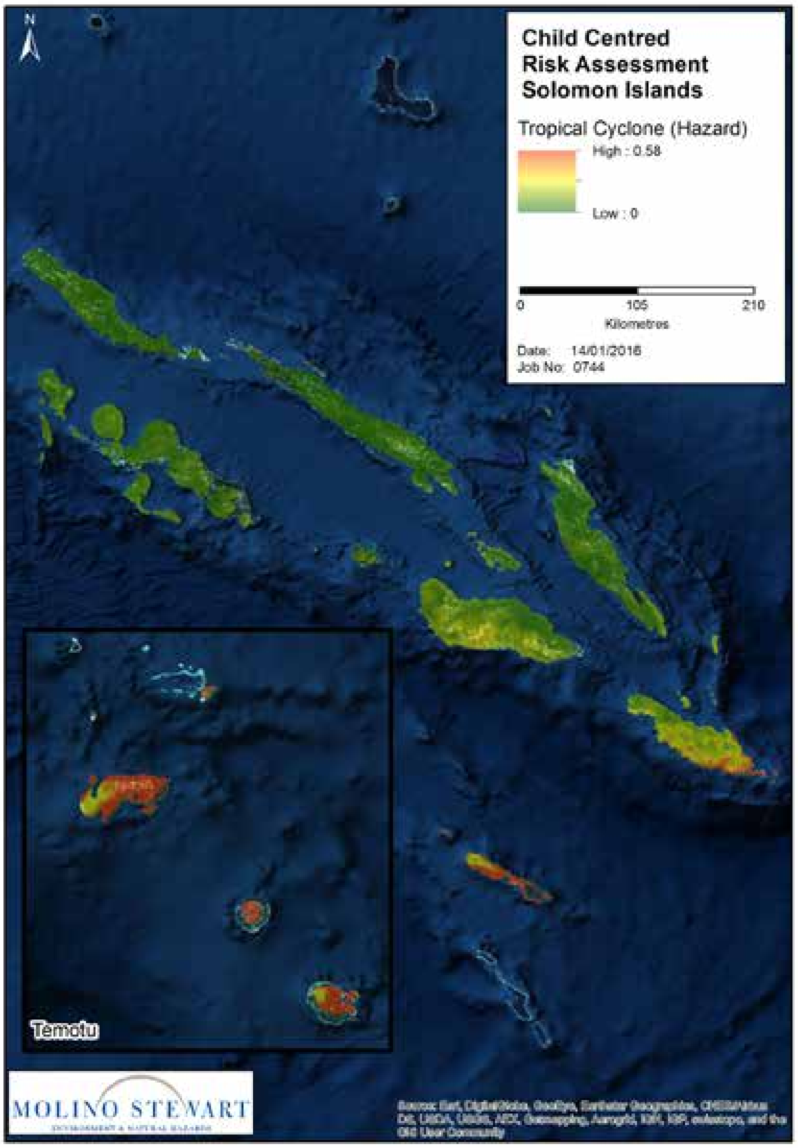
Figure 4. Tropical cyclones' stage-damage curve for the Pacific (SPC, 2013) in relation to the Saffir-Simpson categories



[3] PCRAFI is a joint initiative of SPC, World Bank and the Asian Development Bank, with financial support of the Government of Japan, the Global Facility for Disaster Reduction and Recovery (GFDRR) and the Africa Caribbean Pacific (ACP) – European Union (EU) Natural Disaster Risk Reduction (NDRR) Program, and technical support from AIR Worldwide, New Zealand GNS Science, Geoscience Australia, Pacific Disaster Center (PDC), OpenGeo and the GFDRR Innovation Labs.

Each new damage raster is then multiplied by its return period expressed as a fraction, e.g. a 100-year return period is 0.01, and a 50-year return period is 0.02 to account for the probability of the tropical cyclones generating the damage ratios. The resulting damage and probability product rasters are then added together and normalized to produce a final hazard raster for tropical cyclone where each pixel has incorporated the range of damage caused by the different return periods (Figure 5). Normalized numbers closer to a value of 1 have a higher hazard value.

Figure 5. Geographical distribution of tropical cyclone hazard in Solomon Islands



Earthquake

The hazard data for earthquakes follow the same format as for tropical cyclones and are provided as a raster grid with a resolution of 0.001 degrees, or approximately 1,000 metres. However, the data here are expressed as peak horizontal ground acceleration (m/s2), which is a common measure of earthquake intensity, often expressed as a percentage of gravitation acceleration (9.81 m/s2) and provided for different average return intervals (ARIs) (e.g. once in 100 years). Again, the provided return intervals may vary between countries, but sufficient data are available from PCRAFI for Fiji, Kiribati, Solomon Islands, Vanuatu, Cook Islands, Federated States of Micronesia, Marshall Islands, Nauru, Palau, Samoa, Tokelau, Tonga and Tuvalu, as well as for Papua New Guinea and Timor-Leste.

Just as for tropical cyclones, the destructive capacity of earthquakes is not linear, but follows a stage damage ratio (Figure 6). The earthquake data are thus transformed using the same process as for tropical cyclone into damage (%). The damage is multiplied by the return period expressed as a fraction, before adding them together and normalizing the result (Figure 7). Again, the normalized value of an earthquake hazard is between 0 and 1, where the closer the value to 1, the higher the hazard.

Figure 6. Earthquake stage-damage curve (SPC, 2013) in relation to the Mercalli Scale categories

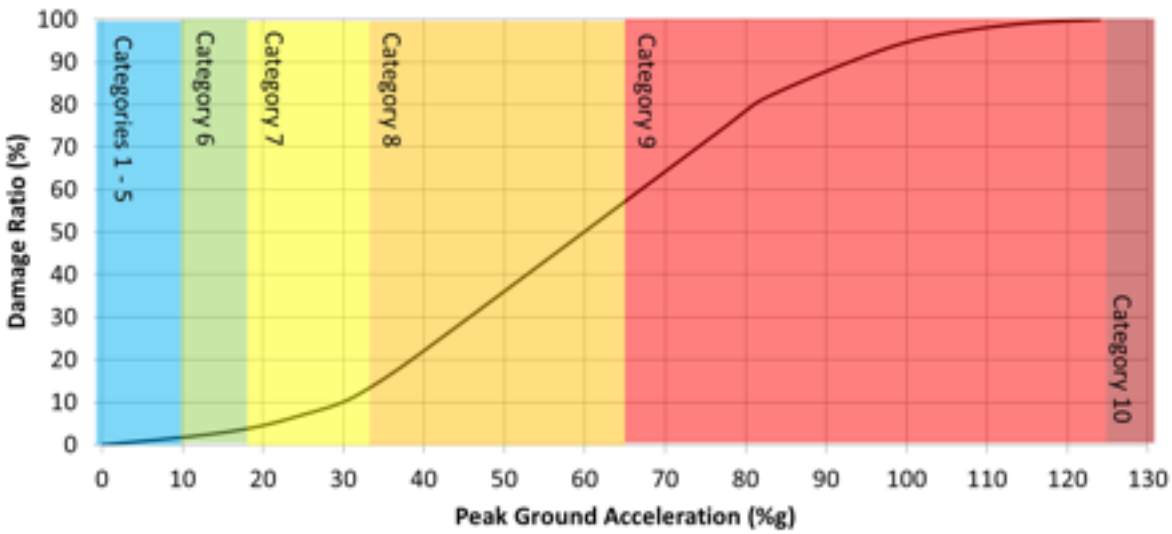
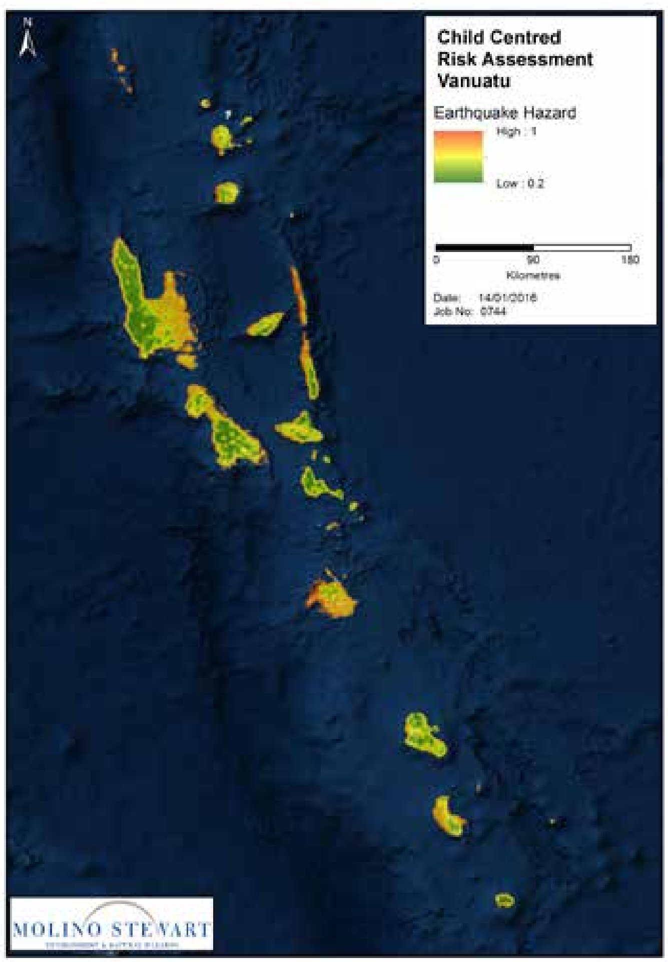


Figure 7. Geographical distribution of earthquake hazard in Vanuatu



It was originally hoped that the provided earthquake data would incorporate the risk of a tsunami, which can be a devastating consequence of earthquakes, often creating more destruction than the earthquake itself. However, no geospatial data for tsunami risk exist yet for the PICTs, and the existing risk assessment in PCRAFI calculated tsunami loss as a function of the earthquake intensity rather than explicitly mapping it across the islands. This, again, is a sign that SPC's Geoscience Division should be resourced to continue and expand their important work.

Drought

Since detailed regional drought data are not available in the same user-friendly format as for tropical cyclones and earthquakes, the drought data are instead drawn from the Global Drought Hazard Frequency and Distribution v1 (1980–2000) dataset developed by Columbia University (Centre for Hazards and Risks Research, 2005). These data were developed utilizing a network of ground rainfall gauges and remotely sensed rainfall data to produce a rainfall time series with a much coarser 2.5-degree resolution. The time series is then used to estimate the median rainfall per month at each pixel, and periods of less than 50 per cent of the median rainfall for three or more consecutive months are identified as drought events. The count of drought events for each pixel thus denotes drought frequency, which is categorized into ten categories, each containing the same number of pixels. Values are therefore given as integers between 1 and 10, where values closer to 10 indicate a higher frequency of drought.

Given that climatic cycles influencing drought may occur over a relatively long period of time (several years), it should be noted that the relatively short time series of 20 years may not be fully representative of the frequency of drought over a long time period. Moreover, the drought data do not provide any details on the severity of the drought, which does not permit any deeper analysis than a simple dichotomous identification of drought or no drought in terms of below or above 50 per cent of the median rainfall for three consecutive months. Even though it is a very broad category between just slightly below median or no rainfall, it is likely that drought in this specific situation would impact vulnerable children,

Another important factor with respect to drought is the water resources that are available. To some extent, this is accounted for within the vulnerability index explained below, but, again, this is a fairly simplistic analysis. For example, if two communities rely on shallow wells for their water supply, the vulnerability index would not differentiate between the two, even if one well is very shallow and easily depleted while the other is deeper and far more resilient to monthly fluctuations of rainfall.

However, this is the available hazard dataset in order to use to at least obtain some indication of the distribution of drought risk. It already takes probability into account in the way that it has been derived, so further processing of the data is not required for use in Child-Centred Risk Assessment.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Child exposure

To assess how exposed children are to the hazards in the analysis, it is vital to first analyse where they are located. This is achieved by combining two main sources of data: (i) census data for each enumeration area through SPC's PRISM project or other sources; and (ii) the building database of SPC's PCRAFI project.

The census data include "functional age groups", which divides the population of each enumeration area into age groups that are representative of different life stages. Child-Centred Risk Assessment focuses on children aged 0 to 18 years old. Since the closest available age group in the census is 15 to 19, the number of children from 15 to 18 must be approximated by proportional interpolation. While the census data for countries may be up to ten years old for some countries, Child-Centred Risk Assessment examines relative risk, limiting the potential misrepresentations introduced by demographic changes to changes in the relative distribution of children between areas. General population growth, therefore, is less of a problem than urbanization, which reduces the population in some areas while increasing it in others. Although the main demographic trend across the Pacific is clear, with a significant movement of people from outer islands or rural areas to urban centres that has the potential to distort the analysis to some extent, these are the only data available, and the results are still valuable for guiding risk-informed decisions until the next census.

To approximate the location of children within each enumeration area, the census data are essentially combined with point shapefile data on buildings extracted from the PCRAFI database to produce a fine-scale raster of children density. The resolution chosen for the raster is 0.001 degrees, or approximately 100 metres, in order to align with the available tropical cyclone and earthquake hazard data.

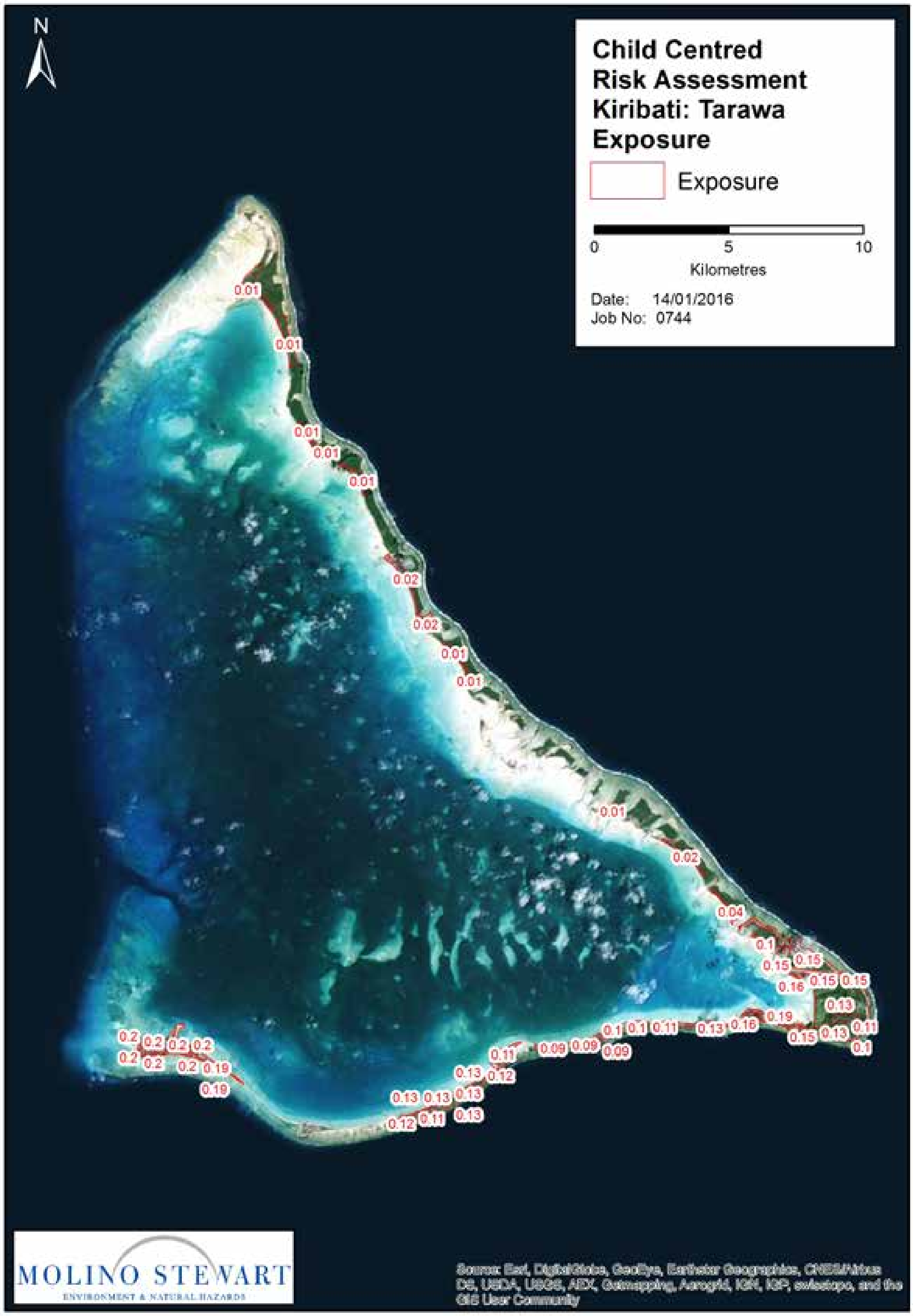
The first steps in the process are to geotag the point building data with the enumeration area and to discern the number of buildings for each enumeration area in GIS-software (ArcGIS) using spatial joins. The next step is to calculate the number of children per building and include this value in the building shapefile. A point density routine is then carried out on the children per building point to produce a density layer of children per area (in this case, decimal degrees). To account for children not always being close to a building and at the same time reduce the possibility of identifying individual properties in rural residential areas, the Point Density routine is set to distribute the children per building over 4x4 pixels in the raster. The child density layer is finally normalized to a value between 0 and 1 to produce an exposure raster layer, where values closer to 1 denote more exposed children (Figure 8).

Approximation of vulnerability

The last part of the process of Child-Centred Risk Assessment for the Pacific is to approximate how vulnerable children in each enumeration area are to the impact of each of the three included hazards. The reason that the level of analysis here must be the enumeration area is that the data available for this part of the analysis are primarily drawn from census data. Other data on potential vulnerability indicators from other sources (e.g. ground surface slope, or population density) are used when available. However, if the purpose of Child-Centred Risk Assessments is to inform regional planning and programming, the same assumptions and similar data must be used across countries. This allows UNICEF to compare the risk across countries and thus risk-inform priorities between countries when necessary. The disadvantage of this approach is that several indicators that would have been useful in assessing vulnerability but are only available for one or two countries are excluded from the analysis. In cases where particular census data are not identical between countries, similar data are used to produce a common vulnerability indicator. The examples of indicators presented in this report are selected for this purpose, but there are no limits to expanding the selection if a country has data on other relevant indicators of vulnerability for even more detailed sub-national analysis.

The first step of the process is to analyse the census data for the country or countries included in the Child-Centred Risk Assessment to identify census questions that can be converted into relevant quantifiable vulnerability indicators.

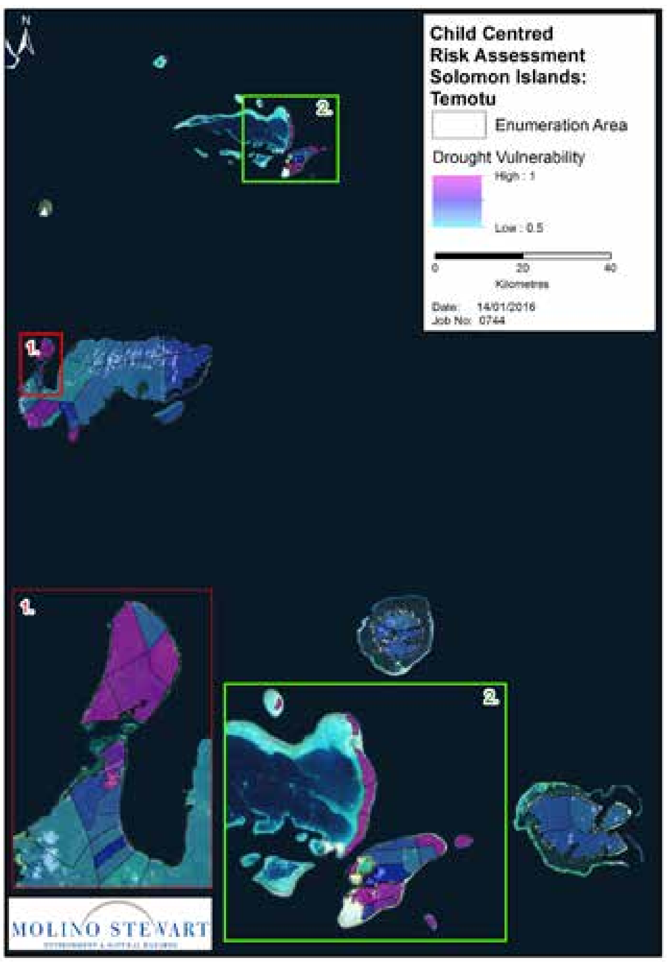
Figure 8. Estimated geographical distribution of child exposure on Tarawa, Kiribati



For example, the number of children under five and the total population of an enumeration area can be transformed into the proportion of population under five, which is an indicator of vulnerability, since children under five are highly dependent on adults in disasters. These vulnerability indicators are based on the judgment and expertise of the project team developing the methodology and should always be open to modification, ideally in dialogue with end users in governments and other partners. However, the format of the available data determines the frames for the analysis as well as its level of detail. The assumptions concerning vulnerability indicators will always contain simplifications, but the resulting Child-Centred Risk Assessment is still a valuable tool for informing dialogue with governments and other partners. Each quantified vulnerability indicator datum is subsequently normalized so that all values are between 0 and 1, where values closer to 1 indicate greater vulnerability. In some cases, this requires inverting the indicator to ensure that, for all indicators, the greater the vulnerability, the higher the value. The vulnerability indicators used in the Child-Centred Risk Assessments for Fiji, Kiribati, Solomon Islands and Vanuatu are presented in Appendix A.

Once the indicators are selected, quantified and normalized, they are weighted according to significance in determining child vulnerability in relation to each of the three hazards. This is achieved by allowing each member of the project team to assign individual weights to each indicator and then to use the average weight in the analysis. The weights range from 1 to 5, where 5 is the most important and 1, the least important. Similarly to the formulation of indicators above, these weightings should also be open to modification, ideally in dialogue with end users in governments and other partners. Finally, the vulnerability index for each hazard is calculated by adding together the products of multiplying all normalized indicator values with their assigned average weight (Equation 1), resulting in a vulnerability score for each enumeration area for each of the three hazards (Figure 9). It is advisable to also carry out a basic sensitivity analysis to see how the resulting vulnerability indices change if assuming more or less conservative weightings.

Figure 9. Geographical distribution of vulnerability to drought in Temotu Province,



Equation 1. Weighted Summation

$$V_{Haz} = i_1 w_1 + i_2 w_2 \ldots + i_x w_x$$

Spatial distribution of risk

Once the three parallel parts of the process of Child-Centred Risk Assessment for the Pacific are completed, a set of maps are produced that contain the geospatial distribution of the hazard, and children's exposure and approximated vulnerability to the hazard. Although these data are important per se, they are now merged into the geospatial distribution of risk. As mentioned above, there are two different risk measures that are important to risk-informed planning and programming – the geographical distribution of a societal risk index, and the geographical distribution of an individual risk index.

The hazard-specific societal risk is calculated by multiplying the values of each pixel for that particular hazard index, the exposure index, and the vulnerability index for that hazard, using GIS-software (ArcGIS). The total societal risk is then calculated by adding together the three hazard specific societal risk indices. It is important to note that the large differences in risk across a country make it difficult to illustrate significant local differences. For instance, the relatively high population density in Suva makes the entire greater metropolitan area stand out in terms of high societal risk (Figure 10), but when zooming into that area, it becomes clear that some areas have significantly higher societal risk than others (Figure 11). To maximize the utility of the risk maps, different scales are used depending on the actual maximum and minimum risk within the included area. Consequently, it is imperative to closely observe the legend of each map before comparing different maps, since the same colours on the maps are likely to signify different levels of risk; by contrast, using the same scale for all maps would hide important local variation.

Figure 10. Geographical distribution of the total societal risk of earthquakes, tropical cyclones and droughts in eastern Fiji

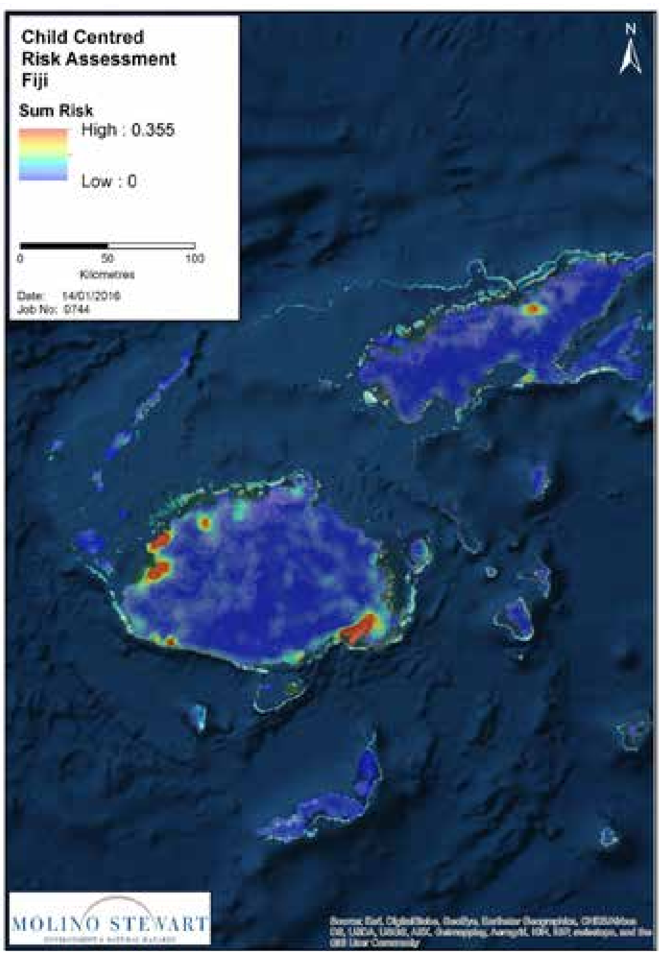
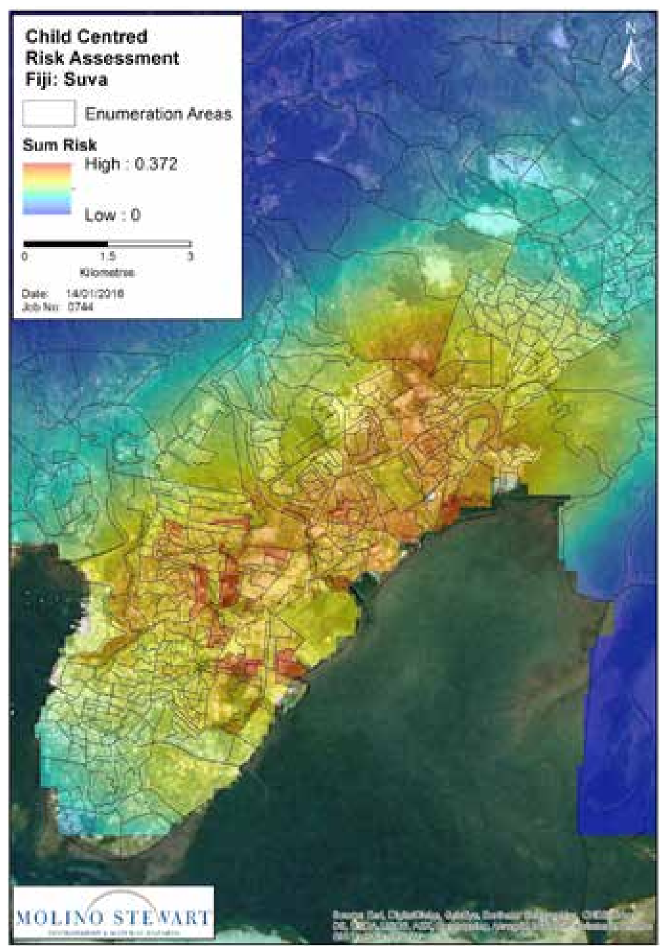


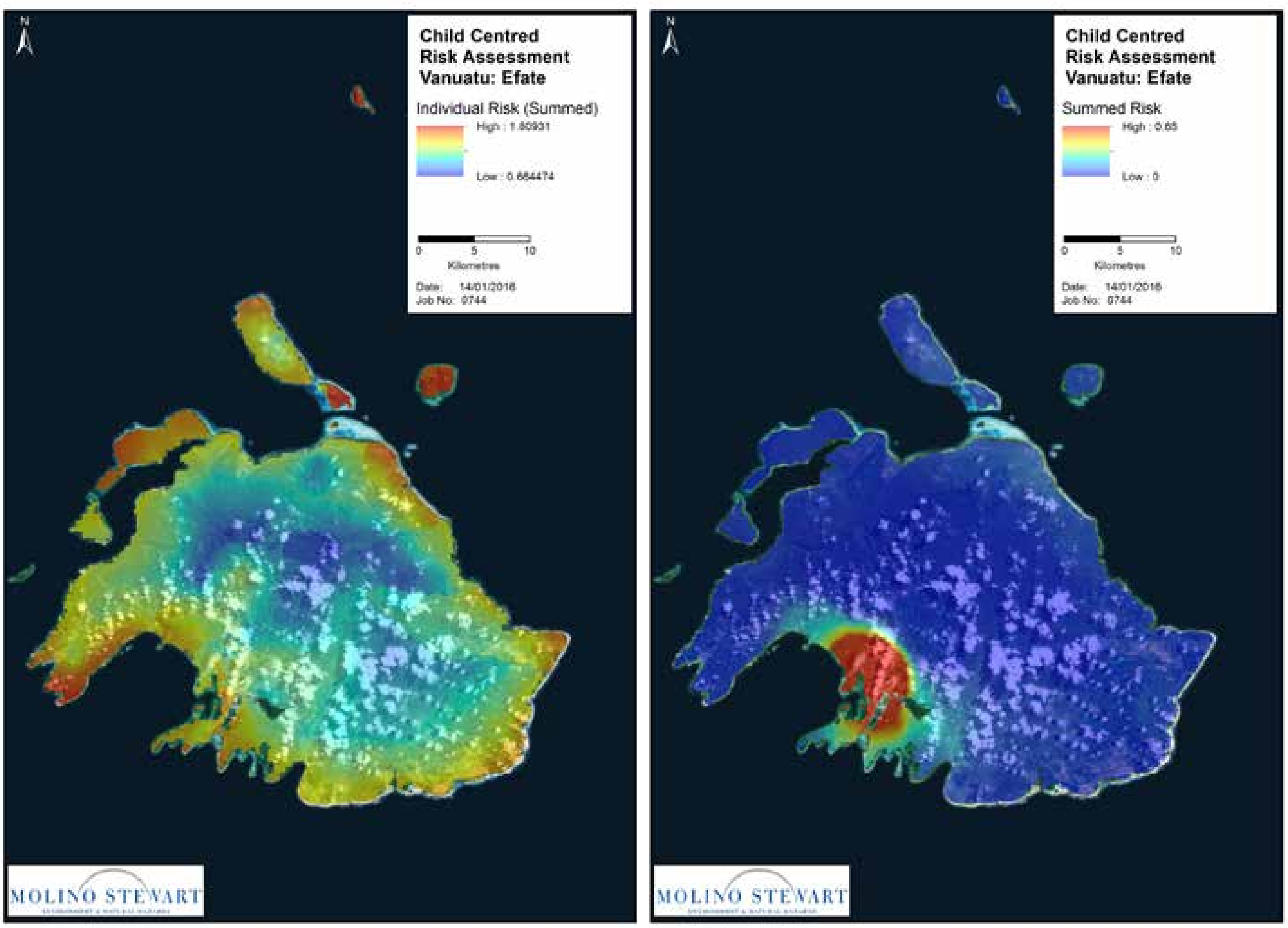
Figure 11. Geographical distribution of the total societal risk of earthquakes, tropical cyclones and droughts in greater Suva area, Fiji



The total individual risk index is calculated in a similar manner to the societal risk index, but without including the exposure index. Multiplying each hazard index with the corresponding vulnerability index and then adding them together, again using GIS-software (ArcGIS), produces the geographical distribution of risk in the form of a relative risk index, which illustrates the risk that one child would be exposed to living in each location. The same issue with scales and level of detail persists, making it vital to be aware of the legend of each map.

The geographical distribution of the societal risk index and the individual risk index are obviously markedly different (Figure 12) and have different purposes in informing planning and programming. The societal risk index provides an illustration of the geographical distribution of risk in terms of what society must manage, which is useful for identifying hotspots where large numbers of children may be anticipated to be affected by disasters. By contrast, the individual risk index illustrates the geographical distribution of risk in terms of what each child is exposed to in each location across the island, which is useful for identifying where the children most at risk are located regardless of how few they may be in one particular location. Both are important for risk-informed planning and programming.

Figure 12. Comparison of the geographical distribution of societal risk (left) and individual risk (right) on Efate, Vanuatu



Conclusions

The children in the PICTs are living in one of the most disaster-prone parts of the world, which is also one of the most vulnerable to the impacts of climate change. In order to fulfil the rights of children and to help forge a sustainable future for them, it is vital to address these challenges through risk-informed planning and programmes. Risk-informing a programme entails grounding two main sets of decisions on risk information: first informed decisions concerning where to focus the programme activities for children at risk, and then informed decisions concerning the design of the programme to address this risk. Child-Centred Risk Assessment is a tool to assist in risk-informing the first set of decisions and could be used at all administrative levels that are significantly involved in decisions regarding spatial priorities in order to address challenges in equity and service delivery across sectors. However, it cannot be used to risk-inform the second set of decisions, for which other risk assessment tools are needed, such as different scenario-based risk assessment methods, which are not discussed here.

Child-Centred Risk Assessment provides the spatial distribution of societal and individual risk, which facilitates identifying hotspots and the most at risk children. However, this information is only one type of information needed for prioritizing where to focus programme activities; sectoral information is also needed to establish the extent to which children have access to appropriate infrastructure and services. Hence, the children most at risk and who have not access to appropriate infrastructure and services should be prioritized in a risk-informed programme.

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Appendix A

Table A1. Used indicators of vulnerability

Indicator	Quantifiable Response	Vulnerability Description
Age 1	Proportion of population under 5	Children under 5 are highly dependent and very vulnerable to natural hazards.
Age 2	Proportion of population between 5 and 14	Children between 5 and 14 are also highly dependent and vulnerable but less so than those under 5.
Age 3	Proportion of population greater than 60	Elderly adults are sometimes dependant on other family members and are typically more vulnerable to natural hazards.
Education	A weighted summation of highest education level achieved	Research has shown that education is a key component of community resilience, and a more educated community is less vulnerable.
Gender Balance	Proportion of population that is female	Research has shown that the higher the proportion of females within the community, the greater the vulnerability. This is particularly true at high ends of the scale, which may be a result of males expatriating for work.

Dwelling Structural Strength	Earthquake: Proportion of buildings with concrete (> Worse), Proportion of buildings with traditional or bure (Light) material (> Moderate), Proportion of buildings with other material (e.g. Wood, Tin, Makeshift) (> Better) Tropical Cyclone: Proportion of buildings with concrete (> Better), Proportion of buildings with traditional or bure (Light) material (> Moderate), Proportion of buildings with other material (e.g. wood, tin, makeshift) (> Bad) Drought: N/A	We have assumed that buildings were constructed in concrete to withstand tropical cyclones and are therefore less vulnerable; however, it is not likely that earthquakes were taken into account in the quality of design and construction, and therefore the heavier materials are likely to be more dangerous. Light materials such as traditional and makeshift ones are more susceptible to damage during the hazard; however, they are likely to be able to be replaced relatively quickly.
Water Supply	Earthquake: Proportion using a piped system (> Worse), Proportion relying on rainfall harvesting (roof) (> Worse) Tropical Cyclone: Proportion relying on rainfall harvesting (roof) (> Worse) Drought: Proportion relying on rainfall harvesting (roof) (> Worse	In an earthquake, it is likely that reticulated (grid or network) water supply systems will fail due to burst water pipes. Similarly, in an earthquake or a tropical cyclone, it is likely that roofs will be damaged and restrict the ability to gather water for rainfall harvesting. In a drought, larger water supply systems, such as reticulation, groundwater or rivers, are likely to be more resilient than rainwater tanks.
Reliable Access	Proportion of households with access to a vehicle	In addition to being a general indicator of wealth, access to a vehicle can be crucial either in evacuating from an impeding cyclone or in recovery. Additionally, vehicles can be used to access alternative water supplies during drought.
Cooking Energy	Proportion of households relying on grid supplied electricity	In a cyclone or earthquake, it is likely that an electricity network will be damaged and can take an extensive amount of time to repair.
Household Tenure	Proportion of households with freehold or own (> Better), Proportion of households in a legal tenant arrangement (> Moderate), Proportion of households other (no agreement, illegal) (> Worse)	This is a general factor of community vulnerability; freehold or ownership is generally less vulnerable than tenancy, and no legal arrangements are generally the most vulnerable.
Communications 1	Proportion of households with access to a land line	Communication in times of disasters is vitally important. The greater the communication networks, the less vulnerable the community.

Communications 2	Proportion of households with access to a mobile phone	Similar to the above, however, recent earthquakes have shown that mobile phones are particularly useful for identifying and rescuing survivors trapped in debris.
Lighting	Proportion of households relying on grid supplied electricity	In a cyclone or earthquake, it is likely that an electricity network will be damaged and can take an extensive amount of time to repair.
Main Toilet	Earthquake: Proportion of households relying on a flush toilet (> Worse), Proportion of households relying on pit or latrine toilets (Moderate) Proportion of populations with no formal toilet (> Better) Tropical Cyclone: Proportion of households relying on a flush toilet (Moderate), Proportion of households relying on pit or latrine toilets (> Worse), Proportion of populations with no formal toilet (> Better) Drought: Proportion of households relying on flush toilets (> Worse)	In an earthquake, it is likely that a piped sewage system, typically related to a flush toilet, will become damaged, and the water supply for the flush toilet will become damaged. In a tropical cyclone, pit or latrine toilets can become water-logged or o damaged. In a drought, flush toilets may not have an adequate water supply.
Slope	Greater average slope	The higher the slope, generally the greater the risk of landslide.
People per Household	Total population over the number of households	The greater the number of people per building, the larger the disaster if that building were to become damaged or destroyed.

* (> Worse) implies the higher the proportion, the greater the vulnerability; (> Better) implies the higher the proportion, the less the vulnerability.